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Pilot Ballooning at Night

The Use of a Fuse to Light a Candle

By F. J. W. Whipple, Sc.D.

The usual method of determining the velocity of the upper winds at night is to send up a pilot balloon carrying a small Chinese lantern and to make observations with a theodolite. The candle in the Chinese lantern is lit shortly before the balloon is released. There is considerable difficulty in preventing the candle from being blown out at the start. The difficulty is reduced by carrying the lantern at the end of a piece of elastic, but I am told that this method is not entirely successful when there is a strong wind and that it is almost impossible to send up a lighted lantern from a ship at sea.

In an article in the April–May 1937 number of the *Journal of the American Meteorological Society* p. 154, Mr. A. F. Spilhaus has described a new method of finding the upper wind at night. He sends up a balloon carrying a fuse which sets light to magnesium flares at intervals. The flares are photographed by a whole-sky camera like the Robin Hill camera. This is a very pretty idea but there is the obvious drawback that it takes time to develop the plate and make a set of measurements with a microscope before the bearings of the flashes can be ascertained. Moreover the fuse cannot be relied on to produce flashes at equal intervals so an observer must stand by to time all the flashes during the ascent of the balloon.

After I had read Spilhaus's paper it occurred to me that it would be practicable to use a fuse to light a candle and thereby obviate

the difficulty generally encountered in sending up a balloon carrying a lantern. The experiment was tried successfully on July 22nd when three balloons were sent up from Kew Observatory. One could watch a balloon fade out of sight and wait until half a minute later a brilliant star suddenly appeared in the sky. This happened in two of our trials; the third was a failure.

The fuses used in the experiments were cut from the cord soaked in lead nitrate solution such as is used for observations in atmospheric electricity. The cord is woven with a hole down the middle. Each fuse was about 10 mm. long; a short piece of wood cut from a safety match and carrying the head of the match was inserted in the fuse which was then fixed to the candle by a piece of thin steel wire. In preliminary experiments it was found that there was a risk of the glowing ash of the fuse falling on the base of the lantern and setting it on fire, some time after the candle was alight. It did not seem possible to prevent the ash falling, but a suggestion of Mr. H. W. Baker's was adopted and the lanterns were well wetted before use.

Naturally one cannot be certain as to why the second of our three trials was a failure, but a possible explanation is that the wire holding the fuse was gripping it too tightly so that the incandescence was not able to travel past the wire. Certainly the failure cannot be attributed to the wind. The stronger the draught the better a fuse burns.

It may be of interest to mention that observers with no previous experience were able to keep the lanterns in sight until 15 minutes and 18 minutes respectively after the release of the balloons. From Kew we were watching tiny lanterns with Christmas-tree candles travelling across unsuspecting Battersea, seven miles away, at a height of a mile and a half.

Cellophane Lanterns for night ascents with Pilot Balloons

By L. N. Larsen

(*of the Meteorological Office, Wellington, New Zealand*).

Somewhat over a year ago, it became necessary for the first time in the New Zealand Service, to make pilot balloon observations regularly before daylight each morning. After some experimenting, a lantern was devised which has given excellent results. The walls are made of cellophane and, since the writer has seen no reference to this material being used elsewhere, the following notes might, it was thought, prove of general interest.

The ordinary tissue-paper lantern as recommended by the Meteorological Office, London, is more flimsy and more liable to catch fire than one of cellophane. Moreover, the former, even if the paper is saturated with thin oil, as well as diffusing the light

coming from the source, absorbs a considerable fraction of it, while with the latter the absorption is negligible. Photometric tests indicated that the intensity of illumination from a cellophane lantern was 1·5 that from one made of tissue paper. Since the lantern, of whatever type, soon becomes a point source, the greater size of the bright surface in the case of the tissue-paper proves to be of no advantage. Actual experience showed that, with the same source of illumination, it was possible to follow the cellophane lantern to considerably greater distances.

Almost all the night ascents at Wellington were made by one man, from the release to the final recording. The theodolite used was by E. R. Watts & Son and was fitted with electric flash lighting for reading the scales. It had variable field-illumination but the latter was not generally used.

The lantern finally adopted as being most efficient under all conditions was made of cellophane 3½ in. diameter by 7 in. high, with a 2 in. aperture in the top. The weight including a wax candle of ¾ in. diameter by ¾ in. long was 10–11 gm. Attachment to the balloon was made by a thread 3 ft. long.

Flights up to 41 minutes duration, reaching an altitude of 6,200 metres and a distance of 12 Km. have been obtained with this type. Lanterns were successfully launched, when the wind velocity ranged from 5 to 55 miles per hour, and remained alight in wind speeds up to 66 miles per hour. The balloons used were mainly of 90 in. circumference rising at 150 metres/minute. Recently, however, the 70 in. balloon with a 10 gm. lantern and rising at 140 metres/minute has been adopted.

As regards the source of light much the best results have been obtained with ordinary candles of the dimensions specified. The amount of illumination is sufficient, and generally greater than that provided by the type of electric lamp which is sometimes used. The candle, also, maintains its brightness whereas the electric lamp decreases in intensity.

Cellophane lanterns can be made quickly as follows: Cut from stiff white paper two sets of circular discs, 5 in. and 3½ in. in diameter, for top and bottom respectively. Punch four holes near the edge of each of the smaller pieces for ventilation purposes, and make some smaller perforations about the centre. A circular aperture 2 in. in diameter is made in the top pieces, and small slots cut round the outer edge ¾ in. in towards the centre. With the edges turned up all round to the depths of the cuts, this makes a top which is conveniently fitted and provides some shelter from draughts. A sheet of uncoloured cellophane 11¼ in. × 8 in. is wrapped around a closed tin of 3½ in. diameter, and the edges lapped and gummed together with cellophane paste. The cellophane is allowed to project beyond the top of the tin. The bottom of the lantern is placed on the latter and the overlapping cellophane pasted down on to it. The tin is then removed and a candle end of the correct length,

which has previously been burned until the meniscus has completely formed is fixed to the bottom of the lantern by means of a few drops of melted wax. The candle is pressed down firmly, and the wax penetrating the perforations in the paper ensures a firm grip. Paste is next applied to the turned-up edge of the paper top which is then slipped inside the cellophane to the required depth with the projections upward. This completes the process. The handle is made of a loop of fine wire or coarse thread.

Ordinary cellophane is used and not the waterproof variety. If desired, cellophane lanterns, can, like paper lanterns be packed flat for storage, but it would be advisable then, to have them made with a flat top.

[Trials of cellophane lanterns were made at the suggestion of Mr. P. N. Skelton, by the British Meteorological Office in 1933. There was some divergence of opinion among observers, but the conclusion was that there was little to choose between cellophane and paper, at any rate up to 10,000 ft. Above that height paper was thought to be better, but on one occasion a lantern of cellophane and one of paper were followed simultaneously up to 15,000 ft. (actual distance not known).—D. N. HARRISON.]

Rainfall and Run-off from Intermittent Streams

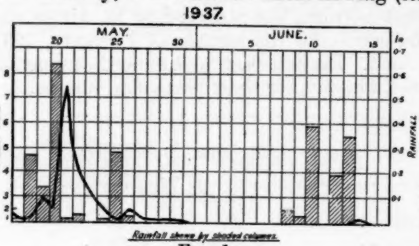
Data regarding the flow of our great rivers, such as the Thames, are of considerable value to water engineers and the like, but some useful facts regarding local climate may be derived from systematic eye observations of the flow of streams in the vicinity of the observer. Observations of intermittent streams are of considerable interest, because one is able to note the period of flow after the cessation of rainfall, and, conversely, the period of rainfall before the re-commencement of flow; which data give a measure of the evaporation and percolation in the soil within the boundary of the catchment area.

During the past three years, observations of the flow of Cuffley Brook, Herts, have been made each day at about 7.45 a.m. This brook, which is an intermittent stream, drains an area of about five square miles* and flows almost all winter and spring, but dries up for varying periods in the summer and autumn months.

The surface of the catchment area consists of about 50 per cent clay, 30 per cent gravel and 20 per cent Reading beds and alluvium. Of this area 65 per cent is grass land and about 35 per cent woodland. The flow of the stream is estimated by eye observation of the approximate depth of water observed each morning to be flowing over the

* See *Meteorological Magazine*, 70, 1935, p. 209.

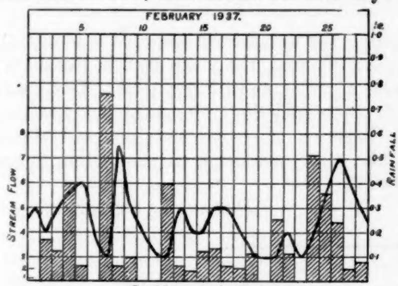
concrete invert of a bridge, and recorded on an arbitrary scale from 0 = bed dry, 1 = trace of water flowing (less than 1 in. depth), to 8 = more than 24 in. depth of water flowing.



Rainfall shown by shaded columns.

FIG. 1

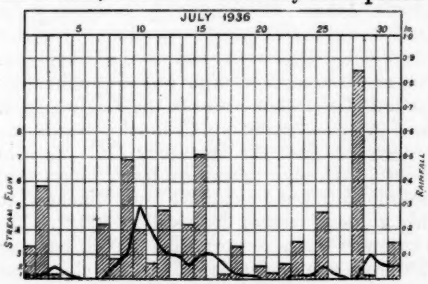
A typical curve of flow is shown, plotted against the corresponding rainfall, in Fig. 1. It will be noted that after the heavy rainfall associated with the thunderstorm on the night of May 20th, the stream rose rapidly and the main flow (run-off) lasted about four days. The thunderstorm of the night of May 25th caused a brief, slight increase in flow, and thence for five days the flow gradually fell off to zero, apparently indicating percolation into the stream-bed from the adjacent soil. The stream was dry for 14 days until the aggregate fall of five rain-days, totalling exactly 1·00 in., gave a trace of flow on the morning of June 15th, which flow, however, had ceased before the observation hour the next morning.



Rainfall shown by shaded columns.

FIG. 2

From data available, it appears that the minimum rainfall required to re-start the flow of the stream, after it has been dry for a period of five or more days, is of the order of 0·50 in.; but the figure varies considerably with the time of the year, the average value being about 0·80 in. Since, however, in every case the actual time of commencement of flow is not known, and in the case of the heavier falls may be some hours before the fixed hour of observation, it seems reasonable to assume that the value of 0·50 in. represents the total



Rainfall shown by shaded columns.

FIG. 3.

amount of moisture which the soil can hold before percolation, or run-off, commences from the catchment area.

An interesting contrast between the stream-flow in winter and summer is shown in the curves for the months of February, 1937, and July, 1936, Figs. 2 and 3. The attached table gives the numerical values of stream-flow, rainfall, etc., for these particular months.

	July, 1936.	February, 1937.
Number of raindays	22	22
Total rainfall	4·29 in.	4·24 in.
Maximum daily fall	0·85 in.	0·76 in.
Number of days flowing ...	22	28
Mean flow	1·55	4·46
Maximum daily flow	5·0	7·5

It will be seen that although the number of raindays is identical, and total falls are approximately equal, the mean flow in February, 1937, was nearly three times as great as in July, 1936. The lower figure for the latter month is apparently due to losses by evaporation, since the mean difference between the solar maxima and shade maxima was 52·8° F. in July, 1936, against a corresponding figure of 27·4° F. in February, 1937.

DONALD L. CHAMPION.

Frontal Irregularity in the Bristol Channel

At 14h. G.M.T. on July 17th, 1937, the writer observed a peculiar distribution of mist in the Bristol Channel. The observation was made from the cliffs near St. Athans, Glamorgan, from which point an extensive view up and down the Channel is possible. The sky was covered with a sheet of thick altostratus and on the Glamorgan side there was no low cloud; the surface wind was approximately WSW., 10 m.p.h. A portion of the view towards the English coast is shown in the sketch, Fig. 1. Looking up Channel towards the Somerset coast it was observed that the Quantock Hills were in cloud, the base being about 600 ft. above mean sea level. Westward of the Quantocks the low cloud thinned out until from Minehead to Lynmouth there was only a line of cumuli, base still at 600 ft. The vertical extent of each cumulus was not more than 300 ft. but was large compared with the cross sectional area. This low cloud was near the Somerset and Devon coast line and above the cloud the visibility was excellent; the whole of the detail of the cliffs and high ground around Dunkerry Hill and Exmoor being visible. But

below the cloud base there was a distinct curtain of mist. This mist extended right down to the surface of the sea and the top edge of it in the gaps between the low cloud appeared to be continuous with the cloud base and quite sharp even when viewed through binoculars. There was a good distribution of ships in the Channel and as far as could be ascertained the mist did not extend more than four miles from the Somerset and Devon coast. The mist appeared to be perfectly uniform and was thin enough to allow the darker colouring of the far coast to show through; it was in this way totally different from sea fog.

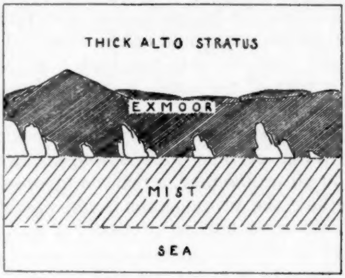


FIG. 1—SKETCH OF VIEW TOWARD ENGLISH COAST.

Down-channel the mist seemed to thin out and disappear somewhere near the Great Hangman (Coombe Martin), but there was some cloud on the hills south-west of Coombe Martin. It was noticed at the time that the whole of the phenomenon lay along the part of the coast where the fall from the high ground to the sea is very sharp: the land rises to 800 ft. within half a mile of the shore for nearly the whole of this stretch of coast. Unfortunately, owing to circumstances it was impossible for the writer to watch the phenomenon for more than half an hour, but during this time it was noticed that each small cumulus seemed to grow as they drifted eastward.

At the time of the observation a cold front, which had passed about two hours previously, was lying along the Mendips; the warm front lay several miles further eastward, both fronts moving forward at a speed of about 20 m.p.h. The cold front stretched south-westwards and was then linked to the next warm front which was approaching Devonshire from the south-west. It will be noticed that the surface wind was still off-shore on the Devon coast even behind the cold front, and the explanation of the rather peculiar distribution of visibility is, in the opinion of the writer, that when the cold air swept in, it did not immediately fall to the surface of the sea after rising over the Devon hills. In fact a pocket of warm air was left under the lee of the Devon and Somerset coast; and so we have the rather unusual condition of lowest cloud on the lee side of the range of high ground. (There is nothing unusual in the idea of an air mass overshooting in this manner: a similar case can be watched where sea fog approaches a high headland. The sea fog rises above and "breaks" over the headland in a similar manner to a breaking water wave). The interesting and important point from the view of the forecaster is that the lee side of high ground

is the very place that is usually spoken of as being least likely to have low cloud; it is usually considered that the windward side of a range of high ground would have the worst conditions, but in the case under discussion the lee side was inferior to even the tops of the high ground. Whether there were similar pockets of warm air in the hollows of the high ground on Exmoor could not be observed; but as the top of the layer of poor visibility was not higher in the narrow valleys opening onto this part of the coast, it is considered that such small pockets were rather improbable.

The factors instrumental in the appearance of the phenomenon therefore appear to be a long range of hills with a well-marked escarpment on the lee side and, in all probability, a not too vigorous flow of air. It is difficult to see how the phenomenon could persist for long with a very turbulent air mass and so probably a fairly smooth approach over the hilltops for the cold air and a slow smooth movement of the warm air, as is possible over sea, are also necessary conditions. It was rather unfortunate that the time during which the phenomenon lasted was unobtainable, for if the explanation here given is correct it is evident that these conditions would be unstable. The rather small scale but vertically elongated cumuli observed were considered to be evidence of this instability.

C. J. M. Aanensen.

OFFICIAL NOTICE

Discussions at the Meteorological Office

The series of meetings for the discussion of recent contributions to meteorological literature especially in foreign and colonial journals, will be resumed at the Meteorological Office, South Kensington, during the session 1937-8. The meetings will be held on alternate Mondays at 5 p.m., beginning on Monday, October 18th, 1937, when Sir George Simpson, K.C.B., C.B.E., F.R.S., will give an account of the results of the Meeting of the International Meteorological Committee to be held at Salzburg in September.

The dates for subsequent meetings will be as follows :—

November 1st, 15th, 29th, December 13th, 1937; January 17th, 31st, February 14th, 28th, March 14th, 1938.

The Director of the Meteorological Office wishes it to be known that visitors are welcomed at these meetings.

Correspondence

To the Editor, *Meteorological Magazine*

Sand Devils

On August 17th about 1300 local time on the Iraq Petroleum Company's aerodrome at Haditha, I had an opportunity (for which I have waited for 10 years) to be in the centre of a large dust devil.

It must be admitted that the experience although unpleasant was very instructive.

The devil as seen from a distance would have been described as having clockwise rotation, rather violent, diameter 20–30 ft., height 300–400 ft. moving if anything slightly into wind.

The actual phenomenon viewed from the interior was somewhat different. First the amount of sand or dust in vigorous rotation was small compared with the amount of sand being raised because about two-thirds of the disturbance was moving linearly and rotation was occurring on the right-hand edge (when facing the direction towards which " devil " was moving). As the wind was from NW. this means that the vigorous clockwise rotation was occurring on the western side. Secondly the air in the disturbance which was not affected by the rotation was moving considerably faster than the undisturbed air. In other words there was a velocity discontinuity at either side of an area 20–30 ft. wide and it was on the discontinuity on the western side that all the rotation was occurring. There may have been a temperature discontinuity as well but I had no means of ascertaining this. Thirdly the advance of the disturbance was characterised by a disturbance of the surface of the ground similar to what happens when dusty ground is watered by the rose of a watering can or water cart. There seemed to be some agency hitting the ground and forcing the dust to rise; the agency can only be descending air.

One eddy formed immediately I entered the disturbance but its life was very short; another formed almost immediately after and became very vigorous carrying sand and dust up to height of 500 ft. The whole thing collapsed about 1½ minutes later when entering the Iraq Petroleum Company's camp. The actual life of the disturbance is not known as it appeared from behind sand dunes but it was probably about 10 minutes.

In this case then the mechanism seemed to be roughly as follows. Over a front of 20–30 ft. the air from some higher level was descending and this air of higher velocity than its environment maintained its identity for some time. The action of the descending air was to force the sand upwards. Rotatory movement was occurring only on the right hand boundary and the direction was clockwise; presumably had the rotation occurred on the left side the rotation would have been anti-clockwise, but there was no indication of this occurring at all; on the left-hand side the line separating clear air from dust-laden air remained a well-defined straight line throughout the whole life of the disturbance.

J. DURWARD.

Meteorological Service, Airport, Baghdad, August 18th, 1937.

Cold Weather in Australia

A correspondent writing from Melbourne under date June 29th,

1937 says, " we usually get sea fogs, two or three at a time, but this year twenty right off, some very dense and not clearing until 2 or 3 p.m., coming on again at night. Now we are having heavy frosts 'like snow' in appearance, followed by a sunshiny day." My correspondent encloses a newspaper cutting describing the River Yarra coated with ice ¼ in. thick.

G. C. WOOLDRIDGE.

51, Nithsdale Avenue, Market Harborough, August 2nd, 1937.

Exceptionally Good Visibility.

The following note has been received from Mr. Seton Gordon of Upper Duntuilm, Isle of Skye.

" On Monday, August 30th, I was able to see the main island of St. Kilda not only from the top of Bruach na Frithe (Cuillin) but, descending in the afternoon, from the corrie almost 1000 ft. below the summit. The distance is I think about 95 miles. From the hill top I could also see Boreray and its stacks where the gannets nest. Very bad weather has followed that extreme visibility and this is the 6th consecutive day of storm."

The wettest place in the British Isles

In the July number of the *Meteorological Magazine* Dr. Glasspoole, writing on the subject of the wettest spots in Great Britain, ignores the record of the old gauge at The Stye at the head of Borrodale in Cumberland, 1,077 ft. above sea-level. This gauge frequently recorded over 200 in., and on three occasions more than 240 in., namely, 1872 (244), 1923 (247), and 1928 (250). This gauge has apparently been discontinued, but I feel sure that its average would have been quite 180 in.

F. J. WARDALE.

Shrewton, Wilts, August 3rd, 1937.

[The computed average rainfall at The Stye, referred to by Mr. Wardale, is 181 in. and attention had been given to this and all other records in the district. Values were quoted, however, for existing gauges which had been inspected and which gave a measure of the increase in rainfall towards the main mountain masses. The heavy rainfall at The Stye is due presumably mainly to Great Gable, but the main masses are further south as mentioned in the article.—J. GLASSPOOLE.]

Dry period on Dartmoor

Mr. Chaplin, who spent the period May to July 1937 at Okehampton, has drawn my attention to the unusually dry weather experienced

there. The record maintained at Uplands, Okehampton, since July 1919 shows that the total rainfall for the three months May to July 1937, viz. 6·22 in. was less than that for the similar period in any other year except 1921, when the total was only 4·76 in. It was very dry also at Newbridge, Dartmoor, a station 1,500 ft. above mean sea level, where the rainfall for the three months was only 7·10 in.

L. F. Lewis.

Thunderstorms of July 19th, 1937

On the evening of July 19th two thunderstorms broke over Horndon-on-the-hill, during the first of which I was watching from my front window, when a ball of fire, simultaneous with a deafening crash of thunder that seemed to convulse the whole region, appeared over the garden bed, not more than 10 or 12 ft. from the window. It was about 18 in. in diameter, and a streak of lightning led down from above on the left, while another came from the ground on the right. The ball was as round as the sun and of the same colour. Although it is difficult to judge of distance under such exciting conditions, it could not have been very far away because there were bushes and trees on the other side of the road, higher than the luminous ball, which would have hidden it from me had it been further off. Two horses were struck and killed by one of the two storms the same evening, so perhaps we had a narrow escape. A similar ball struck a house at Laindon.

James Rhodes.

The Elms, Horndon-on-the-hill, Essex, August 12th, 1937.

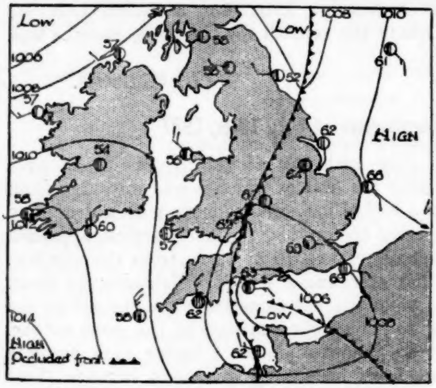
NOTES AND QUERIES

Thunderstorms of July 15th, 1937

On July 15th severe thunderstorms occurred over a wide area in England and Wales, the area extending from north Wales and Somerset and Dorset in the west to the east coast of England. In many areas, notably Gloucester, Somerset and Dorset the storms were accompanied by unusually heavy falls of rain. The following notes relate to the storms as experienced in the Bristol Area. All times are B.S.T.

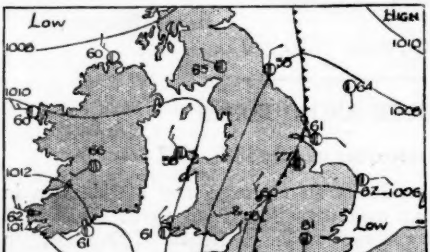
Two distinct storms could be recognised. In the first the rain commenced at Whitchurch at 9.15 a.m. and lasted until 10.45, the storm attaining its greatest intensity shortly after 10.0. During this period 1·12 in. (28·4 mm.) rain fell, of which 0·39 in. (10 mm.) fell in 4 minutes during the period of heaviest rainfall. The second storm broke over Whitchurch shortly before noon and during the period of heaviest rain was of comparable intensity to the first storm. Rain continued without cessation from shortly before noon till

5.40 p.m. yielding 2·16 in. (54·8 mm.) of which 1·28 in. (32·6 mm.) fell between noon and 1 p.m. Further occasional slight rain occurred and not until near dusk did the cloud break. Thunder was last heard at 2.45 p.m. In the City of Bristol severe flooding occurred in the low-lying portions of the city, the storm water invading shops and cellars while whole streets were rendered impassable for a time. The storms, occurring as they did when business and office people were going to their work and during the lunch hour, caused much personal discomfort and inconvenience. The total rainfall for the period 8 a.m. to 7 p.m. at Whitchurch and Horfield amounted to 3·29 in. (84 mm.) and 3·43 in. (87 mm.) respectively. The total fall at Horfield was the largest measured there since 1879 when 3·50 in. (89 mm.) were recorded.



SYNOPTIC CHART, 7H., JULY 1[illegible]TH, 1937.

An examination of the weather charts showed an occlusion extending southwards through Wick to west of Scilly on the evening of the 14th. The system moved slowly eastwards: at Holyhead a thunderstorm occurred about midnight while an observer at Lynmouth reported "slight rain or drizzle about 1 a.m. B.S.T. followed by two peals of thunder about 2 a.m. with moderate rain. By 6 a.m. slight drizzle was falling, becoming intermittent later and ceasing by about 10 a.m." On the 15th the eastward motion was made very slow by a depression which, centred north



SYNOPTIC CHART, 13H., JULY 15TH, 1937

of Bordeaux on the morning of the 14th, had meanwhile moved north to mid-channel by the morning of the 15th. By the early hours of the 16th, the entire system had crossed the east coast of England with the general establishment of north-westerly winds at all levels. At Mildenhall on the morning of the 16th, the upper air was cooler at all levels as compared with the morning of the 15th, by 14° F, at 5,000 ft., 12° F at 10,000 ft., 9° F at 15,000 ft. and 3° F at 25,000 ft.

The intensity and duration of the rainfall was apparently mainly caused by the marked contrast and convergence between the warm moist air from France and the inflowing cooler air from the north-west and the slowing down of the eastward motion of the frontal system over west England.

P. I. MULHOLLAND.

At Beer, South Devon, there were slight showers from thundery clouds at a high level, many of them dissolving, after 21h. G.M.T. on July 14th. On the 15th thunder was frequent from 6 till 12h. G.M.T. The earlier storms were detached, but the main storm (about 9 to 11h.) was in a continuous belt moving slowly from west to east, though the individual cumulonimbus clouds moved from south to north, the height of their base being estimated as not less than 5,000 ft. The lower wind (fractostratus clouds) backed slowly from N. to NW. In south-west England the frontal action was mainly up aloft, though convergence in the lower air no doubt helped the storm. The very high temperatures in western France on the previous evening (93° F. at Rochefort) were significant. Severe storms coming over the Channel are always preceded by high temperature in France.

It was an interesting case of a front from the west, acting as a cold front, moving into a depression of entirely different origin.

C. K. M. DOUGLAS.

Thunderstorms in August

Although in England, August, 1937 was, on the whole, a dry month with an unusual number of days with no measurable rain, severe thunderstorms occurred at times, which were accompanied in some instances by heavy falls of rain in short periods of time. Thunderstorms were reported from a number of places on the 4th; in northern districts of London, flooding resulted from the heavy rain (at Hornsey 1.18 in. of rain fell in 40 minutes). On the 11th, thundery rains occurred locally in eastern England and we read in the press that 1.12 in. fell in about 60 minutes at Ely, Cambridgeshire. Thunderstorms were widespread in western and north-western England and the Midlands on the 12th. We read that at Newport, Monmouthshire, 1.71 in. of rain was recorded in 2 hours and that the hill tops in the direction of Caerleon were white with hail. The observer at

Oughtershaw Hall, Yorkshire, notes that at 3.50 p.m. on the 12th there was a sudden downpour of rain with thunder and lightning and hail like pieces of ice. The Wharfe became a torrent and trees and wooden bridges were swept away. In rather less than 2 hours 2.21 in. of rain fell.

The severe thunderstorms on the 13th were scattered throughout the British Isles, rainfall totals for the 24 hours ended on the evening of the 13th, amounting to 3.89 in., 2.56 in., 2.54 in. and 2.13 in. at such widely separated stations as Montrose, Portland, Nairn and Kew Observatory respectively while the total at Warrington was 3.16 in. for the 24 hours ending on the morning of the 14th. In London, streets were flooded and traffic disorganised over a wide area; at Hornsey 2.53 in. fell in 2 hours, at Kingston Grammar School 2.15 in. in 2 hours and at Kew Observatory 2.05 in. in 105 minutes.

Heavy hail was a feature of thunderstorms experienced in south-east England on the 30th. *The Times* of the 31st reported; "A pilot arriving (at Croydon) from France said that on the whole route from the south coast the ground appeared to be covered with hailstones . . . . At Wallington, Surrey, hailstones, some of them measuring $\frac{3}{4}$ in. in diameter, fell for half an hour". We hear from a resident at Bromley, Kent, that "hail which fell at about 5.30 p.m. was still on the roof (between the gables) when I left the next morning, and also a small patch in the garden." The rainfall recorded at Bromley, Kent, was 1.65 in., nearly all of which fell in one hour.

L. F. Lewis.

The Prediction of Minimum Screen Temperatures at Aldergrove on Winter Nights

An investigation into minimum temperature prediction at Aldergrove on similar lines to that conducted at Larkhill, and noted by Mr. Andrews in the *Meteorological Magazine* for April 1934, p. 61 has been undertaken. Data were available for the years 1929–36.

The amount of cooling $(T\text{–}M)$ was plotted against $(T\text{–}D)$ as suggested by Col. Gold* and the following formula derived (see Fig. 2) :—

$$(T\text{–}M) = -3\cdot5 + \tfrac{1}{4}T + \tfrac{11}{20}(T - D).$$

where T = 16h. temperature in °F.
M = minimum temperature in °F.
and D = dew point temperature at 16 h.

Comparing formulae for Larkhill, Catterick and Aldergrove we have :—

Larkhill $(T - M) = 5\cdot5 + \tfrac{3}{20}T + \tfrac{2}{5}(T - D).$
Catterick $(T - M) = -7 + \tfrac{7}{20}T + \tfrac{1}{2}(T - D).$
Aldergrove $(T - M) = -3\cdot5 + \tfrac{1}{4}T + \tfrac{11}{20}(T - D).$

***London, Met. Mag.*, 69, 1934, p. 88.

Thus for a set of given conditions there is less cooling at Aldergrove than at either Larkhill or Catterick.

Conditions at the Aldergrove site are undoubtedly influenced, with

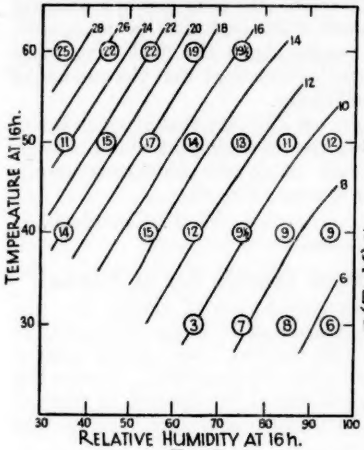


Fig. 1

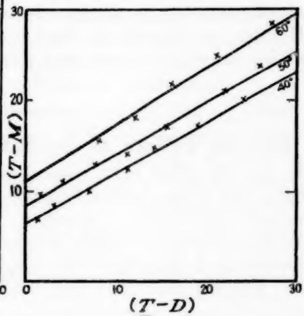


Fig. 2

westerly winds, by the proximity of Lough Neagh, a shallow stretch of water 140 sq. miles in extent and lying only two miles to the west. Temperatures of Lough Neagh at a point on the eastern shore have

TABLE I

Mean difference between 16h. temperature and minimum screen temperature on clear or partly clear nights at Aldergrove, October to March, 1929—36.

Temperature 16h.	25°–34°F.	35°–44°F.	45°–54°F.	55°–64°F.
Wind Velocity (m.p.h.) ...	0–12	0–12	0–12	0–12
Rel. Hum. 16h.	Temperature Difference $(T-M)$°F.			
90–100 per cent	(6)	9	12	..
80– 89 „	8	9	11	..
70– 79 „	7	9½	13	15½
60– 69 „	(3)	12	14	(19)
50– 59 „	..	15	17	22
40– 49 „	..	..	(15)	(22)
30– 39 „	..	(14)	(11)	(25)

Figures in brackets indicate 5 occasions or less.

been taken daily during 1936 and a rough analysis indicates that the water temperature fluctuates widely from day to day, the range of

fluctuation naturally being less than that of the screen temperature. The main effect of the proximity of this large expanse of water is presumably to increase the humidity, hence the decreased cooling compared with Larkhill and Catterick. On calm nights a drainage of cold air from the higher ground to the east must be considered.

A comparison of the three results shows the final term fairly constant and bears out Mr. Flower's deduction† that the amount of cooling is dependent largely on locality.

This investigation also brought out the fact that the number of nights cloudless throughout to be expected during the winter months, October to March, is surprisingly small, the Aldergrove results giving only 7 per cent over the winters 1929–36.

W. F. PEATFIELD.

Was the Failure of the Spanish Armada due to Storms?*

It has for long been almost a commonplace of history that the complete failure of the Spanish Armada in 1588 was due mainly to unseasonably stormy weather. Mr. Holland Rose, after a detailed analysis of the circumstances attending the expedition, reverses this dictum and finds that the winds favoured the Spanish as often as the English fleet, but that the Spaniards completely failed to take advantage of their opportunities.

The meteorological history of these two eventful months begins with the Spanish fleet advancing up the Channel on July 20th with a light SW. wind. On the 23rd both fleets were becalmed off Portland Bill, but on the 24th a NE. wind sprang up at dawn, shifting later to SE. and then to SSW. Again on the 25th off the Isle of Wight a calm gave place to a freshening westerly wind, which continued until the 28th. On the 29th the decisive battle of Gravelines was fought in a moderate SSW. wind, veering to WSW.

The defeated Spaniards fled northwards before south-westerly winds, strong about August 5th. Two ships were lost on the coast of Norway, but the greater part of the fleet passed safely between the Orkneys and Shetlands with the aid of a timely NE. wind—which might well have been regarded as an interposition of Providence not against them but in their favour. From August 8th to 15th the wind was mainly south-easterly, keeping the Armada safely away from the west coast of Scotland. There was a storm off Rockall on August 22nd, but it was not until September that the broken fleet, approaching too near the west of Ireland in quest of water which could have been taken aboard with ease from northern Scotland, was caught and shattered by westerly gales on the 2nd and 10th.

Bearing in mind the seas traversed, we must agree with the

†*London, Met. Mag.*, 69, 1934, p. 232.

* By J. Holland Rose. Reprinted from the *Proceedings of the British Academy*, Vol. 22. London, Price 3*s*. net.

author that this record presents nothing beyond what should have been reasonably expected and guarded against. The thesis is admirably presented and makes a valuable addition to the literature of weather and war.

C. E. P. Brooks.

REVIEW

Meteorology of Great Floods in the eastern United States. By Charles F. Brooks and Alfred H. Thiessen. Reprinted from the Geographical Review, Vol. 27, No. 2, April, 1937, pp. 269–90.

The unprecedented floods in the Ohio River in January, 1937, briefly described in the *Meteorological Magazine* for February, p. 17, were due to extremely heavy rainfall concentrated along a rather narrow belt in the eastern States. The authors examine the meteorological situation accompanying this heavy rainfall and compare it with previous floods. In all cases the heavy rain was associated with a sharply defined front between a great current of warm moist tropical air from the Gulf of Mexico and Carribbean Sea, driven north by a persistent anticyclone near Bermuda, and a wedge of cold polar continental air from Canada. Under these conditions, while the eastern United States is abnormally warm, the west is abnormally cold. In January, 1937, oranges were freezing in southern California while they were ripening too fast in Florida. The greatest floods occur in winter and early spring not because the rainfall is heaviest then but because the frozen or saturated ground facilitates run-off. The melting of snow seldom contributes much directly to great floods but it may help to maintain the temperature contrast between the warm and cold air masses, and so intensify the rainfall along the front.

BOOKS RECEIVED

The dependence of terrestrial temperatures on the variations of the sun's radiation. By C. G. Abbot. Smithson. Misc. Coll., Vol. 95, No. 12, Washington D.C., 1936.

Bulletin de l'Observatoire de Talence (Gironde), 3rd Series, Nos. 19–26, Talence, 1936 and 1937.

NEWS IN BRIEF

We learn that Professor V. Conrad of Vienna University has been elected an honorary member by the Hungarian Meteorological Society, Budapest.

We learn that Dr. E. G. Mariolopoulos has resumed his post of Professor of Meteorology at the University of Salonica and Director of the Meteorological and Climatological Institute of the University.

The Weather of August, 1937

Pressure was highest north of the Azores and east of the White Sea, reaching about 1024mb. in each area. Pressure was below 1005mb. between Iceland and Greenland and over the New Siberian Islands, and below 1000mb. north of the Persian Gulf. Over Europe pressure decreased eastwards from 1019mb. in Ireland to 1011mb. in south-eastern Russia. No data were received for North America. Pressure was above normal over the northern half of Europe, the excess being more than 5 mb. from Ireland to the Urals and reaching 12mb. east of the White Sea. Pressure was below normal over southern Europe and south-western Asia and over most of the Arctic, the deficit reaching 7mb. in Greenland.

Temperature was lowest (31.5° F.) at Cape Chelyuskin. The isotherm of 40° F. ran from east Greenland in 70° N. across the north of Spitsbergen and Novaya Zemlya and along the arctic coast of Russia. Most of Ireland, Scotland, and the north of Scandinavia, Finland, northern Russia and the greater part of Siberia were between 50° and 60° F. England and the greater part of Europe were between 60° and 65° F., the Mediterranean lands 70–80° F. and the Nile Valley 83–94° F. The highest temperature reported, 99.5°, was at Shaibah near the Persian Gulf. Temperatures were more than 5° F. above normal over Scandinavia and Finland and east of the Caspian and 4–6° F. below normal in western Siberia; elsewhere the deviations were small. The British Isles and western Europe were 1–4° F. above normal.

Rainfall was abundant in central Europe, falls of 4–5 in. being nearly twice the normal for August, but the British Isles and Scandinavia were in general relatively dry. The Mediterranean lands, as is usual at this season, were dry.

In the southern hemisphere pressure was above 1020mb. over New Zealand and 1018 to 1021mb. over the southern half of Australia and Tasmania, decreasing northwards to an area of low pressure (1009mb.) over the Bismarck Archipelago. Pressure was more than 5mb. above normal over New Zealand and Tasmania, but below normal over Australia north of 32° N., New Guinea, the Bismarck Archipelago, and the islands of the west Pacific south of 10° S.

Temperature was about 80° F. in 10° S., decreasing southwards over Australia to 70° F. in 18° S., 60° F. in 25° S., and 50° F. along the south coast. In New Zealand the temperature decreased from 50° F. in the north to 45° F. in the south. New Zealand and the southern half of Australia were generally about 2° F. above normal; elsewhere the deviations were irregular.

In Australia the northern and central regions had little or no rain, while in the south and east totals were generally between 1 and 3 in. but the differences from normal were slight. New Zealand was relatively dry.

Apart from local thunderstorms the weather over the British Isles during August was mainly warm, dry and sunny, but with much morning mist or fog. Sunshine totals were above normal except along the eastern and northern coasts, Ilfracombe reporting over 60 hours more than the average, and rainfall showed a marked deficiency over the greater part of the country. New low rainfall records were registered at Gorleston (0.28 in.) where the records began in 1871 and at Cranwell (0.43 in.) where records began in 1917 and absolute droughts were established at a number of places in southern England. At Kew Observatory it was the warmest August since 1932 and at Renfrew the mean maximum of 67.6° F. was the highest for August since records began there in 1920. From the 1st to 4th a belt of high pressure covered the British Isles giving warm sunny weather generally with much morning mist or fog, which however on the 2nd and 3rd lasted throughout the day on parts of the east coast. Over 13 hrs. bright sunshine occurred at several places in the west and north on these days, 14.6 hrs. at Lerwick on the 2nd, and 13.9 hrs. at Morecambe on the 3rd. On the 4th a depression approaching from the Atlantic caused rain generally in Ireland and west Scotland and from then to the 19th depressions passed across the country in an easterly direction at first with their main centres to the north of the British Isles, but later with their centres further south. Apart from thunderstorms the weather continued generally fair and sunny in the south with rain locally on the 6th, 9th, 10th, and 16th, but unsettled conditions with rain at times though long bright periods were experienced in Scotland, Ireland and north England. Thunderstorms occurred in England and south Scotland on the 3rd, 4th and 6th, were widespread over the whole of the British Isles on the 12th to 14th and in Scotland on the 18th, those on the 12th to 14th being accompanied in some places by heavy rain which caused flooding*. The sunniest days of the period over the country generally were the 7th, 8th and 15th, 14.8 hrs. at Morecambe on the 7th, 13.8 hrs. at Bude on the 8th and 13.7 hrs. at Chester on the 15th, and in the south most days except the 14th were sunny. Temperature was high generally between the 5th and 13th, reaching 92° F. at Greenwich on the 6th and Tunbridge Wells on the 7th and exceeding 80° F. at many places on several days. On the 13th in the rear of one of the depressions passing across the country temperatures fell somewhat and remained about normal until after the 19th. Much morning mist or fog was experienced on the 5th, 6th, 10th to 13th, and occasionally lasted during the day in parts of the eastern coasts, the English Channel and St. George's Channel. On the 19th a wedge of high pressure extended north-east from the anticyclone near the Azores and from then to the 29th pressure remained high over the country generally with fair sunny weather except in the northern

* See p. 189.

districts which came at times under the influence of the depressions to the north—this was especially so on the 24th to 25th when the rain area from the depression to the north extended over Ireland, Scotland and north England with gales in north Scotland on the 24th. In the south-west the sunny days continued until the 30th, but in the south-east after the 25th the days though dry were mainly overcast. Temperature was high generally exceeding 70° F. at many places in the south on most days while among the largest amounts of sunshine recorded were 13.8 hrs. at Morecambe on the 21st and 13.5 hrs. at Tiree on the 26th. Much morning mist or fog occurred during this time. Temperature fell generally in the north on the 29th and thunderstorms occurred in many parts of England on the 30th, sometimes accompanied by hail. By the 31st a deep depression was approaching from the Atlantic and rain fell generally in the west and north. The distribution of bright sunshine for the month was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway ...	116	−12	Chester ...	185	+26
Aberdeen ...	127	−13	Ross-on-Wye ...	202	+30
Dublin	165	+11	Falmouth ...	229	+33
Birr Castle ...	160	+23	Gorleston ...	160	−37
Valentia... ...	164	+16	Kew	210	+27

Kew, Temperature, Mean 65·5° F., Diff. from normal + 2·8° F.

Miscellaneous notes on weather abroad culled from various sources.

The great glacier lake of Demmevann above the Hardangerfjord burst its confines on the 11th and the resultant flood of water, boulders and iceblocks fell into the Simo Valley and destroyed 16 farms—the 130 inhabitants clambered up the mountainside to safety. The flood originated in the glacier of Hardangerjockel near Rembesdalskjaak above Lake Demmevann. A waterspout struck the zone between Borgovecchio and Gea Marina (north Italy) on the 16th, killing four children and injuring 50 people. During a violent thunderstorm, accompanied by hail and heavy rain, at Massa, on the west coast of Italy, thousands of birds were dashed from the trees there and killed. A large avalanche which is an unusual event at this season, occurred on the Blickenspitze in Tirol owing to a sudden fall in the temperature. (*The Times*, August 12th–30th.)

More than 50 people have been drowned as the result of extensive floods in various districts of Burma at the beginning of the month. A fortnight's incessant heavy rain caused the rivers Gogra and Rapti in the central and eastern parts of the United Provinces to overflow their banks by the 18th isolating hundreds of villages—by the 23rd the flood waters were gradually subsiding. Delhi and east Punjab on the other hand were suffering from lack of rain. (*The Times*, August 4th–24th.)

Many bush and forest fires had been experienced in Newfoundland

by the 9th owing to the prolonged heat and drought. Violent thunderstorms occurred in New York State on the 11th and again on the 22nd, after which the prolonged heat wave with high humidity ended. In the United States temperature was above normal, especially in the Missouri Valley about the middle of the month, while rainfall was mainly below normal during the first part of the month becoming generally above normal in the eastern and central States later. (*The Times*, August 6th–24th, and *Washington D.C., U.S. Dept. Agric., Weekly Weather and Crop Bulletin.*)

Daily Readings at Kew Observatory, August, 1937

Date	Pressure, M.S.L. 13h.	Wind, Dir., Force 13h.	Temp. Min.	Temp. Max.	Rel. Hum. 13h.	Rain.	Sun.	Remarks. (see vol. 69, 1934, p. 1).
	mb.		°F.	°F.	%	in.	hrs.	
1	1023·4	NE.3	55	76	62	—	9·0	
2	1023·6	NE.2	55	76	65	—	11·4	w early.
3	1019·9	NW.1	55	81	56	—	8·3	w m early.
4	1017·7	S.2	57	82	51	—	6·8	w early.
5	1018·7	SW.2	62	80	52	—	5·1	pr_0 8h.–9h.
6	1016·6	SSW.3	59	85	48	—	12·2	w early.
7	1014·8	N.2	62	82	51	—	12·2	w early.
8	1019·4	N.2	58	77	46	—	11·2	
9	1020·6	SW.3	58	79	46	—	11·7	
10	1017·7	SW.3	64	76	60	0·10	3·1	r_0 2h.–3h., R 16h.–
11	1013·8	WSW.2	63	78	67	trace	4·3	r_0 3h.–4h. [17h.
12	1012·2	NE.3	60	80	55	—	9·6	tl 21h.
13	1008·0	N.3	63	72	79	2·14	2·0	TLR 15h.–17h.
14	1008·2	W.2	62	69	96	0·53	0·0	R 12h.–13h. & 16h.–
15	1012·6	W.4	51	67	47	—	11·0	[17h.
16	1010·1	SW.3	54	69	59	0·21	5·8	r_0–r 17h.–20h., R 20h.
17	1007·8	W.3	59	72	58	—	7·7	pr_0 2h. [–21h.
18	1016·2	SW.3	58	72	57	—	3·4	
19	1020·5	W.4	55	68	47	—	10·1	w early.
20	1022·0	NW.3	52	68	52	—	7·9	w early.
21	1019·7	NW.4	56	66	76	—	5·7	r_0 8h. & 10h.
22	1021·7	N.2	54	71	61	—	9·5	w evening.
23	1021·6	N.2	52	75	51	—	10·5	w early.
24	1020·6	SSW.2	54	77	53	—	10·5	w early.
25	1021·6	Calm	56	76	55	—	3·9	w early.
26	1025·6	NE.3	59	69	71	—	0·5	w m early.
27	1027·0	NE.2	58	64	74	—	0·0	d_0 8h.
28	1022·4	NNW.1	55	67	75	—	1·9	w evening.
29	1021·2	N.1	55	71	66	—	2·8	w early.
30	1020·4	SSW.2	53	75	64	—	4·4	w early.
31	1018·4	S.2	55	77	61	—	7·6	w m early.
*	1018·2	—	57	74	60	2·98	6·8	* Means or Totals.

General Rainfall for August, 1937

England and Wales ...	46	per cent of the average 1881–1915.
Scotland	91	
Ireland	76	
British Isles	63	

Rainfall : August, 1937 : England and Wales

Co.	Station.	In.	Per cent of Av.	Co.	Station.	In.	Per cent of Av.
Lond .	Camden Square..........	1·34	61	*War* .	Birminghm, Edgbaston	·97	36
Sur .	Reigate, Wray Pk. Rd..	1·50	61	*Leics* .	Thornton Reservoir ...	·67	24
Kent .	Tenterden, Ashenden...	1·63	71	„ .	Belvoir Castle............	·76	29
„ .	Folkestone, Boro. San.	1·01	...	*Rut* .	Ridlington	1·40	56
„ .	Margate, Cliftonville....	1·42	74	*Lincs* .	Boston, Skirbeck.........	.59	25
„ .	Eden'bdg., Falconhurst	2·53	97	„ .	Cranwell Aerodrome...	·43	16
Sus .	Compton, Compton Ho.	1·77	57	„ .	Skegness, Marine Gdns.	·73	30
„ .	Patching Farm..........	1·54	61	„ .	Louth, Westgate.........	·53	19
„ .	Eastbourne, Wil. Sq....	1·80	73	„ .	Brigg, Wrawby St.......	1·49	...
Hants.	Ventnor, Roy.Nat.Hos.	1·64	82	*Notts* .	Worksop, Hodsock......	·20	8
„ .	Fordingbridge, Oaklnds	1·20	46	*Derby*.	Derby, The Arboretum	·30	11
„ .	Ovington Rectory.......	1·28	47	„ .	Buxton, Terrace Slopes	1·35	31
„ .	Sherborne St. John......	1·29	53	*Ches* .	Bidston Obsy.............	1·63	53
Herts .	Royston, Therfield Rec.	1·10	43	*Lancs*.	Manchester, Whit. Pk.	1·23	36
Bucks.	Slough, Upton............	1·28	59	„ .	Stonyhurst College......	2·89	57
„ .	H. Wycombe, Flackwell	1·45	60	„ .	Southport, Bedford Pk.	1·37	39
Oxf .	Oxford, Radcliffe.........	·44	19	„ .	Ulverston, Poaka Beck	2·52	47
N'hant	Wellingboro, Swanspool	2·28	96	„ .	Lancaster, Greg Obsy.	2·64	58
„ .	Oundle	1·11	...	„ .	Blackpool	2·02	56
Beds .	Woburn, Exptl. Farm...	2·36	102	*Yorks*.	Wath-upon-Dearne......	·27	11
Cam .	Cambridge, Bot. Gdns.	·88	37	„ .	Wakefield,Clarence Pk.	·56	22
„ .	March.......................	1·60	67	„ .	Oughtershaw Hall.......	4·34	...
Essex.	Chelmsford,County Gdns	·71	33	„ .	Wetherby, Ribston H..	1·18	43
„ .	Lexden Hill House......	1·13	...	„ .	Hull, Pearson Park......	·77	26
Suff .	Haughley House..........	·85	...	„ .	Holme-on-Spalding......	·96	36
„ .	Rendlesham Hall........	1·41	71	„ .	West Witton, Ivy Ho.	1·41	48
„ .	Lowestoft Sec. School...	·44	20	„ .	Felixkirk, Mt. St. John.	1·39	49
„ .	Bury St. Ed., WestleyH.	3·06	118	„ .	York, Museum Gdns....	1·79	71
Norf. .	Wells, Holkham Hall...	1·21	50	„ .	Pickering, Hungate......	1·80	70
Wilts .	Porton, W.D. Exp'l. Stn	1·13	50	„ .	Scarborough...............	·74	27
„ .	Bishops Cannings.........	·93	30	„ .	Middlesbrough............	1·13	41
Dor .	Weymouth, Westham.	....	...	„ .	Baldersdale, Hury Res.	1·33	38
„ .	Beaminster, East St....	1·07	34	*Durh* .	Ushaw College............	2·14	74
„ .	Shaftesbury,Abbey Ho.	1·78	61	*Nor* .	Newcastle, Leazes Pk...	2·55	90
Devon.	Plymouth, The Hoe....	·86	28	„ .	Bellingham, Highgreen	3·09	85
„ .	Holne, Church Pk. Cott.	·90	20	„ .	Lilburn Tower Gdns....	2·94	104
„ .	Teignmouth, Den Gdns.	1·38	61	*Cumb*.	Carlisle, Scaleby Hall...	2·09	51
„ .	Cullompton	·99	33	„ .	Borrowdale, Seathwaite	6·00	55
„ .	Sidmouth, U.D.C.........	1.59	...	„ .	Thirlmere, Dale Head H.	3·85	50
„ .	Barnstaple, N. Dev.Ath	1·33	39	„ .	Keswick, High Hill......	3·15	60
„ .	Dartm'r,Cranmere Pool	2·00	...	*West* .	Appleby, Castle Bank...	1·57	48
„ .	Okehampton, Uplands.	·99	23	*Mon* .	Abergavenny, Larchf'd	1·09	37
Corn .	Redruth, Trewirgie......	1·19	35	*Glam* .	Ystalyfera, Wern Ho....	1·26	20
„ .	Penzance, Morrab Gdns.	·63	20	„ .	Treherbert, Tynywaun.	1·04	...
„ .	St. Austell, Trevarna...	55	15	„ .	Cardiff, Penylan..........	·38	9
Soms .	Chewton Mendip..........	·97	22	*Carm* .	Carmarthen,M. & P. Sch.	1·80	38
„ .	Long Ashton..............	2·01	57	*Pemb* .	St. Ann's Hd, C. Gd. Stn.	·73	23
„ .	Street, Millfield..........	1·58	....	*Card* .	Aberystwyth	1·35	...
Glos .	Blockley	·81	...	*Rad* .	BirmW.W.Tyrmynydd	1·04	19
„ .	Cirencester, Gwynfa....	·59	20	*Mont* .	Lake Vyrnwy	2·13	41
Here .	Ross-on-Wye..............	·87	34	*Flint* .	Sealand Aerodrome......	1·47	...
Salop.	Church Stretton.........	1·39	43	*Mer* .	Blaenau Festiniog	4·60	45
„ .	Shifnal, Hatton Grange	·73	26	„ .	Dolgelley, Bontddu......	1·10	20
„ .	Cheswardine Hall........	·96	29	*Carn* .	Llandudno	1·67	59
Worc .	Malvern, Free Library...	·43	15	„ .	Snowdon, L. Llydaw 9..	6·85	...
„ .	Ombersley, Holt Lock.	1·29	48	*Ang* .	Holyhead, Salt Island...	1·61	51
War .	Alcester, Ragley Hall...	1·26	45	„ .	Lligwy	·98	...

Rainfall: August, 1937: Scotland and Ireland

Co.	Station.	In.	Per cent of Av.	Co.	Station.	In.	Per cent of Av.
I. Man	Douglas, Boro' Cem....	2·20	58	*R&C* .	Achnashellach	3·38	51
Guern.	St.Peter P't.Grange Rd.	·43	18	„ .	Stornoway,C.GuardStn.	4·05	...
Wig .	Pt. William, Monreith.	2·23	58	*Suth* .	Lairg......	2·25	71
„ .	New Luce School........	2·89	65	„ .	Skerray Borgie............	1·88	...
Kirk .	Dalry, Glendarroch........	3·60	75	„ .	Melvich........	2·14	72
Dumf.	Dumfries, Crichton R.I.	2·25	59	„ .	Loch More, Achfary....	3·44	59
„ .	Eskdalemuir Obs........	3·85	75	*Caith* .	Wick	3·09	112
Roxb .	Hawick, Wolfelee........	2·91	87	*Ork* .	Deerness	2·35	82
Peeb .	Stobo Castle........	3·44	97	*Shet* .	Lerwick	1·93	69
Berw .	Marchmont House......	2·87	87	*Cork* .	Dunmanway Rectory...	...	...
E.Lot .	North Berwick Res.....	...	...	„ .	Cork, University Coll...	1·78	53
Midl .	Edinburgh, Blackfd. H.	4·13	129	„ .	Mallow, Longueville....	1·72	55
Lan .	Auchtyfardle	3·92	...	*Kerry*.	Valentia Observatory...	2·96	62
Ayr .	Kilmarnock, Kay Park	3·34	...	„ .	Gearhameen........	3·60	47
„ .	Girvan, Pinmore........	3·80	85	„ .	Bally McElligott Rec...	2·45	...
„ .	Glen Afton, Ayr San. ...	2·44	45	„ .	Darrynane Abbey........	3·21	74
Renf .	Glasgow, Queen's Park	3·57	101	*Wat* .	Waterford, Gortmore...	1·85	49
„ .	Greenock, Prospect H..	3·69	68	*Tip* .	Nenagh, Castle Lough.	...	...
Bute .	Rothesay, Ardencraig...	4·24	87	„ .	Roscrea, Timoney Park	...	...
„ .	Dougarie Lodge........	4·67	110	„ .	Cashel, Ballinamona....	2·44	70
Arg .	Loch Sunart, G'dale....	5·64	99	*Lim* .	Foynes, Coolnanes......	2·02	52
„ .	Ardgour House........	4·37	...	*Clare* .	Inagh, Mount Callan....	4·76	...
„ .	Glen Etive........	4·74	63	*Wexf* .	Gorey, Courtown Ho...	1·47	44
„ .	Oban........	3·69	...	*Wick* .	Rathnew, Clonmannon.	1·35	...
„ .	Poltalloch........	4·29	88	*Carl* .	Bagnalstown,Fenagh H.	2·48	71
„ .	Inveraray Castle........	7·19	109	„ .	Hacketstown Rectory...	4·21	104
„ .	Islay, Eallabus........	3·68	84	*Leix* .	Blandsfort House......	2·13	54
„ .	Mull, Benmore........	9·40	80	*Offaly*.	Birr Castle........	3·33	87
„ .	Tiree	3·54	84	*Kild* .	Straffan House........	3·86	102
Kinr .	Loch Leven Sluice......	5·50	144	*Dublin*	Dublin, Phoenix Park..	2·34	74
Fife .	Leuchars Aerodrome...	3·42	111	*Meath*.	Kells, Headfort........	3·51	85
Perth .	Loch Dhu........	5·20	77	*W.M* .	Moate, Coolatore........	2·22	...
„ .	Crieff, Strathearn Hyd.	4·05	96	„ .	Mullingar, Belvedere...	2·27	54
„ .	Blair Castle Gardens....	2·76	82	*Long* .	Castle Forbes Gdns......	2·67	65
Angus.	Kettins School........	4·28	117	*Gal* .	Galway, Grammar Sch.	2·86	69
„ .	Pearsie House........	2·88	...	„ .	Ballynahinch Castle....	3·91	71
„ .	Montrose, Sunnyside...	5·44	195	„ .	Ahascragh, Clonbrock.	3·51	84
Aber .	Balmoral Castle Gdns..	1·74	57	*Rosc* .	Strokestown, C'node......	...	...
„ .	Logie Coldstone Sch....	1·96	62	*Mayo*.	Blacksod Point........	4·85	106
„ .	Aberdeen Observatory.	2·71	99	„ .	Mallaranny	6·32	...
„ .	New Deer School House	1·79	60	„ .	Westport House........	3·55	88
Moray	Gordon Castle........	2·60	82	„ .	Delphi Lodge........	7·65	89
„ .	Grantown-on-Spey	2·20	69	*Sligo* .	Markree Castle........	3·97	92
Nairn.	Nairn	5·43	225	*Cavan*.	Crossdoney, Kevit Cas..	3·14	...
Inv's .	Ben Alder Lodge........	3·32	...	*Ferm* .	Crom Castle........	4·11	99
„ .	Kingussie, The Birches.	2·57	...	*Arm* .	Armagh Obsy........	2·93	81
„ .	Loch Ness, Foyers	3·65	119	*Down*.	Fofanny Reservoir........	4·13	...
„ .	Inverness, Culduthel R.	5·67	222	„ .	Seaforde	2·41	64
„ .	Loch Quoich, Loan........	3·18	...	„ .	Donaghadee, C. G. Stn.	2·76	83
„ .	Glenquoich........	4·25	52	*Antr* .	Belfast,Queen's Univ....	3·26	113
„ .	Arisaig House........	4·51	78	„ .	Aldergrove Aerodrome.	3·36	93
„ .	Glenleven, Corrour......	...	...	„ .	Ballymena, Harryville.	4·14	97
„ .	Fort William, Glasdrum	4·56	...	*Lon* .	Garvagh, Moneydig....	4·80	...
„ .	Skye, Dunvegan........	6·84	...	„ .	Londonderry, Creggan.	4·08	88
„ .	Barra, Skallary........	2·68	...	*Tyr* .	Omagh, Edenfel........	3·99	93
R&C .	Alness, Ardross Castle.	...	...	*Don* .	Malin Head........	3·13	...
„ .	Ullapool........	1·68	47	„	Dunkineely........	3·55	...

Climatological Table for the British Empire, March, 1937

STATIONS.	PRESSURE. Mean of Day M.S.L.	PRESSURE. Diff. from Normal.	TEMPERATURE. Absolute. Max.	TEMPERATURE. Absolute. Min.	TEMPERATURE. Mean Values. Max.	TEMPERATURE. Mean Values. Min.	TEMPERATURE. Mean Values. ½ Max. and Min.	TEMPERATURE. Mean Values. Diff. from Normal	TEMPERATURE. Mean. Wet Bulb.	Relative Humidity.	Mean Cloud Am'nt	PRECIPITATION. Am'nt.	PRECIPITATION. Diff. from Normal.	PRECIPITATION. Days.	BRIGHT SUNSHINE. Hours per day.	BRIGHT SUNSHINE. Percentage of possible.
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	0–10	in.	in.			
London, Kew Obsy.	1004·6	− 8·8	55	26	45·3	34·5	39·9	− 3·3	35·1	87	7·1	2·76	+ 1·07	18	3·6	31
Gibraltar	1016·0	− 1·1	63	45	59·0	50·4	54·7	− 2·9	50·4	82	6·1	5·35	...	17	...	...
Malta	1014·3	+ 0·1	75	46	63·2	53·5	58·3	+ 1·2	53·5	77	4·2	0·83	− 0·65	3	8·6	72
St. Helena	1010·5	− 1·9	74	62	70·6	63·7	67·1	+ 2·0	64·8	95	9·4	6·06	+ 2·04	27	...	...
Freetown, Sierra Leone	1009·7	+ 0·7	91	71	88·0	76·1	82·1	...	76·6	79	5·3	6·01	+ 4·85	7	...	...
Lagos, Nigeria	1008·9	0·0	94	73	89·8	78·5	84·1	+ 0·7	77·8	85	6·8	5·05	+ 1·30	7	7·6	63
Kaduna, Nigeria	1009·4	...	99	59	97·0	64·0	80·5	− 0·6	60·2	47	2·5	0·05	− 0·49	1	9·1	76
Zomba, Nyasaland	1008·2	− 1·4	86	60	81·0	64·6	72·8	+ 1·5	68·5	78	6·6	2·07	− 7·01	8	...	...
Salisbury, Rhodesia	1010·4	− 1·1	85	48	80·3	56·8	68·5	+ 0·3	61·8	67	4·0	2·53	...	8	8·4	69
Cape Town	1014·1	− 0·4	94	53	78·4	60·0	69·2	+ 1·1	60·1	78	5·2	1·86	+ 0·98	6	...	...
Johannesburg	1011·2	− 1·2	82	41	75·8	53·6	64·7	+ 1·3	55·9	66	3·0	2·63	− 1·81	10	9·2	75
Mauritius	1010·6	− 1·3	87	70	83·8	73·4	78·6	+ 0·6	75·7	83	6·6	9·14	+ 0·55	19	6·9	57
Calcutta, Alipore Obsy.	1009·1	− 0·8	97	61	91·2	69·6	80·4	+ 0·2	70·0	80	3·9	0·38	− 1·00	1*	...	...
Bombay	1009·5	− 1·4	90	67	84·9	71·5	78·2	− 1·3	70·2	74	2·1	0·00	− 0·02	0*	...	...
Madras	1009·6	− 1·3	93	68	88·9	73·8	81·3	+ 0·2	75·7	76	4·0	0·00	− 0·34	0*	...	...
Colombo, Ceylon	1009·4	− 0·7	89	71	87·2	74·3	80·7	− 1·1	77·4	75	4·6	6·48	+ 2·20	11	9·1	75
Singapore	1008·2	− 1·5	92	72	87·9	75·8	81·9	+ 0·7	77·8	78	5·9	6·93	+ 0·47	13	7·5	62
Hongkong	1012·5	− 3·5	81	51	68·6	61·4	65·0	+ 1·7	62·2	89	9·1	3·45	+ 0·51	17	1·7	14
Sandakan	1008·8	...	90	74	88·5	76·1	82·3	+ 1·3	77·5	80	6·7	0·65	− 7·82	8	...	...
Sydney, N.S.W.	1016·6	+ 0·3	95	56	77·1	63·3	70·2	+ 0·9	64·1	68	5·8	9·06	+ 4·08	13	6·8	56
Melbourne	1017·0	+ 0·1	92	48	77·1	54·9	66·0	+ 1·5	58·9	68	4·5	1·24	− 0·94	10	7·4	60
Adelaide	1017·6	+ 0·5	98	50	83·9	61·9	72·9	+ 3·0	61·5	44	4·7	1·05	+ 0·03	6	7·8	64
Perth, W. Australia	1014·2	− 1·1	95	52	81·6	61·8	71·7	+ 0·5	61·3	57	3·4	0·15	− 0·66	6	9·7	80
Coolgardie	1013·9	− 1·0	99	47	81·5	60·2	70·9	− 1·0	61·7	69	5·0	4·86	+ 3·92	9	...	...
Brisbane	1015·1	+ 0·7	97	63	81·8	66·4	74·1	− 0·2	68·4	73	5·1	7·26	+ 1·49	12	6·5	54
Hobart, Tasmania	1015·9	+ 1·7	87	45	67·1	52·1	59·6	+ 0·3	53·7	64	6·3	1·47	− 0·23	11	6·4	52
Wellington, N.Z.	1017·4	+ 0·2	74	43	64·4	53·8	59·1	− 1·5	56·0	82	8·5	2·22	− 1·11	13	5·4	44
Suva, Fiji	1008·4	0·0	92	72	86·2	75·6	80·9	+ 0·8	76·7	83	6·3	17·53	+ 3·04	26	5·8	48
Apia, Samoa	1008·1	− 1·1	89	71	85·6	74·2	79·9	+ 0·6	77·3	81	6·0	16·15	+ 2·17	26	6·0	49
Kingston, Jamaica	1013·1	− 1·8	89	66	85·5	69·0	77·3	+ 0·2	67·0	81	1·6	0·01	− 1·01	1	7·7	64
Grenada, W.I.	1011·0	− 2·0	90	71	86	73	79·5	+ 1·7	73	74	4	1·35	− 1·31	16	...	...
Toronto	1015·2	− 2·1	45	9	34·7	22·5	28·6	− 1·0	...	...	5·9	1·48	− 0·93	12	4·9	41
Winnipeg	1023·4	+ 4·2	48	−21	26·5	7·7	17·1	+ 2·1	...	...	6·4	0·28	− 0·88	7	5·4	45
St. John, N.B.	1007·1	− 7·0	47	5	35·4	20·7	28·1	− 0·3	23·1	72	5·6	2·66	− 1·88	14	5·4	45
Victoria, B.C.	1014·1	− 1·8	61	36	51·7	40·6	46·1	+ 2·6	43·0	82	8·0	1·35	− 1·08	13	4·2	35
Addendum: Grenada, W. I.—January—	1011·3	− 1·5	88	71	85	72	78·5	+ 1·4	73	74	5	5·53	+ 1·15	21	—	—

* For Indian stations a rain day is a day [illegible]

Grenada, W. I.—January—	1011·3	— 1·5	88	71	85	72	78·5	+ 1·4	73	74	5	5·53	+ 1·15	21	—	—